Sept. 20, 1938. I. G. WILSON 2,130,517

GAIN CONTROL CIRCUITS

Filed May 28, 1937

FIG. 1

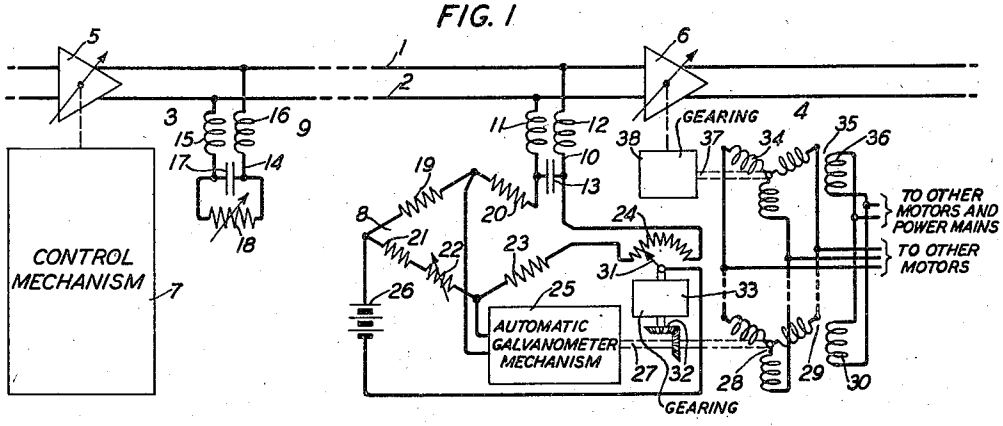


FIG. 2

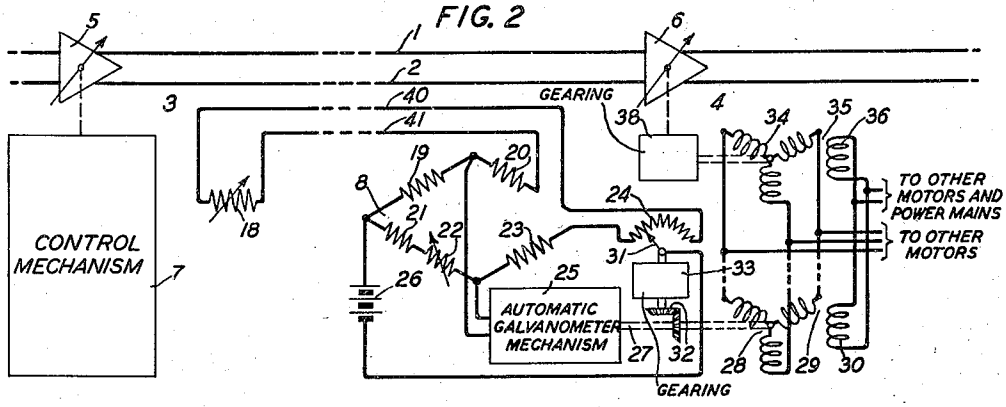
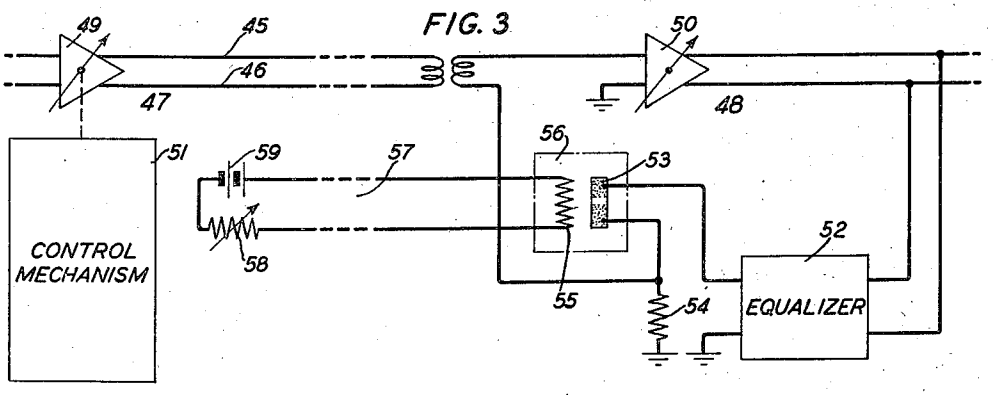


FIG. 3



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GAIN CONTROL CIRCUITS

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10 Claims. (Cl. 178—44)

This invention relates to gain control circuits for transmission lines and particularly to pilot wire gain control circuits for transmission lines.

One object of the invention is to provide a gain control circuit for controlling the gain at a station on a transmission line by a pilot path extending to an associated station that shall have the setting of the gain adjusted at the associated station.

Another object of the invention is to provide a gain control circuit having a pilot path extending between unattended and attended stations on a transmission line that shall adjust the gain at an unattended station by changing the resistance of the path at an attended station.

Another object of the invention is to provide a gain control circuit having a pilot line extending between unattended and attended stations on a transmission line with a high temperature coefficient resistance at the unattended station under control of the pilot line for controlling the gain at the unattended station that shall have the resistance of the pilot line adjusted at the attended station to set the gain effected at the unattended station.

On transmission lines, as for example, a carrier cable transmission line, it is necessary to place repeater or gain control stations at intervals along the cable. These stations may be of the type disclosed in the patent to Fred A. Brooks, No. 2,075,975, April 6, 1937, if so desired. Some of the gain control stations are attended and other of the gain control stations are unattended. At times it is desirable to change the setting of the gain at a repeater station. At an attended station the level at which the gain is effected may be conveniently adjusted whereas at an unattended repeater station it has heretofore been inconvenient to adjust the setting of the gain controlling apparatus without sending a repeater attendant to the station.

According to the invention, it is proposed to adjust the setting of the gain at an unattended station from an attended station without the addition of any extra control circuit between the two stations. Thus the attendant at any attended station may not only control the setting of the gain at the attended station but may also control the setting of the gain at an unattended station.

A cable carrying a large number of lines comprising transmission circuits may have attended and unattended stations thereon. The attended gain control station will be provided with a pilot path extending from the unattended station to an attended station. The pilot path may be a pair of wires in the cable which serve for transmission purposes or may be a separate pair of wires in the cable. The pilot path in one instance may serve as a part of a bridge at the unattended station. The bridge may operate a galvanometer control mechanism of the type disclosed in the patent to I. G. Wilson, No. 2,086,105, July 6, 1937, for controlling the gain of an amplifier or may control galvanometer control mechanism of the type disclosed in the patent to F. A. Brooks, No. 2,075,975, April 6, 1937. The pilot path is subjected to the same temperature changes as the transmission line or lines whose gain is to be controlled. The resistance variation in the pilot path according to temperature changes govern a bridge circuit which in turn governs the galvanometer control mechanism to govern the gain control amplifier at the unattended station.

In order to permit setting of the gain at the unattended station from the attended station, an adjustable resistance element is inserted in the pilot path at the attended station. The adjustable resistance is varied by the attendant at the attended station to change the setting of the bridge at the unattended station and accordingly to adjust the setting of the gain at the unattended station.

In a modification of the invention, the pilot path may be supplied by a source of current for heating a coil at the unattended station. The coil at the unattended station controls the heating of elements of silver sulphide or boron, which have a high temperature coefficient of resistance. The elements having a high temperature coefficient of resistance are inserted in the control circuit of the gain control amplifier at the unattended station. The resistance of the pilot path which controls elements having high temperature coefficients of resistance is adjusted at the attended station in the same manner as above set forth to adjust the setting of the gain at the unattended station.

In the accompanying drawing, Fig. 1 is a diagrammatic view of a gain control circuit constructed in accordance with the invention;

Fig. 2 is a modification of the gain control circuit shown in Fig. 1 of the drawing; and

Fig. 3 is a modification of the gain control circuit shown in Fig. 1 of the drawing, wherein a resistance element having a high temperature coefficient of resistance is employed to control the gain.

Referring to Fig. 1 of the drawing, a transmission line comprising conductors 1 and 2 is shown, having two gain control stations 3 and 4 connected thereto. The conductors 1 and 2 forming the transmission line may be a pair of wires in a cable containing many other transmission lines controlled by the apparatus at the gain control stations. The station 3 is assumed to be an attended gain or repeater station and the station 4 is assumed to be an unattended gain or repeater station. An amplifying repeater 5, which is preferably of the thermionic type, is provided at the attended station 3 and a similar amplifying device 6 is provided at the unattended

gain control station 4. The amplifying device 5 at the attended station 3 is governed by control mechanism 7 which may be of the type disclosed in the F. A. Brooks patent, No. 2,075,975 or of the type disclosed in the patent to I. G. Wilson, No. 2,086,105, July 6, 1937. It is understood that the control mechanism at the station 3 is governed by a pilot line (not shown) of any suitable type.

The unattended station 4 which controls the gain of an amplifying device 6 is governed by a bridge circuit 8. The bridge circuit 8 is controlled by a pilot path 9 extending between the two stations 3 and 4. The pilot path 9 extending between the attended and unattended stations forms a part of the bridge circuit. As illustrated, the pilot path 9 comprises a direct current path on the transmission conductors 1 and 2 which form the transmission line. The bridge circuit 8 is connected to the conductors 1 and 2 by means of a filter 10 comprising series inductive elements 11 and 12 and a condenser 13. The filter 10 serves to permit the flow of direct current and to insure against a transmission of any signal currents to the bridge circuit. A similar filter 14 comprising inductance elements 15 and 16 and a condenser 17 is provided at the distant terminal of the pilot path 9, located at the attended gain control station 3. The end of the pilot path 9, located at the attended station, is terminated by means of an adjustable resistance element 18. The adjustable resistance element 18 is under the control of the operator at the attended station and serves to adjust or set the level about which the regulation of the gain at the unattended station is affected.

The bridge circuit 8 comprises resistance elements 19, 20, 21, 22, 23 and 24. The resistance element 24 is adjustable for rebalancing the bridge circuit after each operation of the apparatus at the unattended station. Automatic galvanometer mechanism 25 of the type referred to in the above-mentioned patent to F. A. Brooks, No. 2,075,975, is connected across two opposite vertices of the bridge 8. A battery 26 is connected across the other two vertices of the bridge 8. The automatic galvanometer mechanism 25 operates a shaft 27, which in turn drives the rotor 28 of a master motor 29. A stator winding 30 of the master motor 29 is connected to a suitable source of alternating current (not shown). The shaft 27 is also connected to an arm 31 controlling the resistance 24 by means of bevel gear wheels 32 and a gear box 33 containing suitable change gears.

The rotor winding of the rotor 28 is connected to the rotor winding of a rotor 34 on a service motor 35. The service motor 35 is provided with a stator winding 36 connected to the same source of alternating current connected to the stator winding of the main motor 29. Other smaller service motors (not shown) may be connected in parallel to the main motor 29, as indicated in the drawing. The rotor 34 of the service motor 35 is connected by a shaft 37 to a gear box 38, which controls the gain of the amplifying device 6 in the manner disclosed in the above-mentioned patent to F. A. Brooks, No. 2,075,975.

In the apparatus above disclosed, a change in temperature on the transmission conductors 1 and 2 will cause not only a change in the attenuation of the transmission line but also a change in the resistance of the pilot path 9. The change in the resistance of the pilot path 9 will unbalance the bridge circuit 8 and operate the automatic galvanometer mechanism 25 for changing the gain at the unattended station by means of the amplifying device 6 to correct for the change in the line attenuation. At this time the adjustable resistance element 24 is varied to rebalance the bridge circuit. It is necessary at times to adjust the setting of the gain control apparatus at the unattended station. This change of the setting of the gain is affected by adjusting the resistance element 18 at the attended station 3. The resistance element 18 as before set forth forms the terminal of the pilot path 9 for the unattended station.

Referring to Fig. 2 of the drawing, a system very similar to the system shown in Fig. 1 is illustrated, having the gain control apparatus at the unattended station controlled by a pilot path having two conductors positioned adjacent to the transmission line. Like parts in Fig. 2 to those shown in Fig. 1 will be indicated by similar reference characters.

The pilot path for the bridge 8 at the unattended station 4 comprises two conductors 40 and 41, which are preferably a pair of wires in a position adjacent to the pair of wires 1 and 2 forming the transmission line. The pilot path comprising the conductors 40 and 41 is terminated at the attended station by means of an adjustable resistance 18, which serves to effect adjustment of the gain at the unattended station 4. The circuits shown in Fig. 2 operate in the same manner as the circuits shown in Fig. 1 and a detailed description thereof is deemed unnecessary.

Referring to Fig. 3 in the drawing, a transmission line comprising conductors 45 and 46 is provided with an attended gain control station 47 and an unattended gain control station 48. The attended gain control station 47 is provided with an amplifying device 49 and the unattended station 48 is provided with an amplifying device 50. The amplifying devices 49 and 50 may be of the type referred to in describing the amplifying devices 5 and 6 in Fig. 1 of the drawing. The amplifying device 49 at the attended station 47 may be governed by control mechanism 51 similar to the control mechanism 7 referred to when describing the circuits shown in Fig. 1 of the drawing.

The gain control device 50 shown in Fig. 3 of the drawing is governed by a feedback circuit comprising a suitable equalizer 52, a resistance element 53 having a high temperature coefficient of resistance and a resistance element 54. The resistance element 53 may be composed of silver-sulphide, barium, or any other suitable material. The resistance element 53 is mounted with a heating coil 55 within a suitable oven 56. The heating coil 55 terminates a pilot line 57 which extends from the unattended station 48 to the attended station 47. At the attended station 47, an adjustable resistance element 58 is provided for controlling the setting of the gain of the amplifying device 50 from the attended station. Thus by adjusting the resistance element 58 it is possible to adjust the level at which the gain at the unattended station 48 is regulated by means of the pilot line 57. A battery 59 which may be located at any suitable point is provided for heating the coil 55.

Changes in temperature to which the transmission line comprising the conductors 45 and 46 is subjected not only vary the attenuation of the transmission line but also vary the resistance of the pilot line 57. Change in the resistance of

the pilot line **57** changes the heating of the silver-sulphide element **53** by the heating coil **55**. Variations in the resistance of the silver-sulphide element **53** varies the feedback circuit for the amplifying device **50**. The feedback circuit is connected to the input circuit of the amplifying device **50** by means of the resistance element **54**, as shown in the drawing.

Modifications in the circuits and in the arrangement in location of parts may be made within the spirit and scope of the invention and such modifications are intended to be covered by the appended claims.

What is claimed is:

1. In a signal transmission line having an attended gain control station and an unattended gain control station thereon, a gain control path extending between said stations, gain control means in the line at the unattended stations, means controlled by the resistance variations of said path to govern said gain control means, and means located at said attended station for controlling said path to govern the setting of said gain control means.

2. In a signal transmission line having an attended gain control station and an unattended gain control station thereon, a gain control path extending between said stations, a gain control amplifier located at said unattended station, means controlled according to the resistance variations of the path to govern the gain of said amplifier at the unattended station, and means located at said attended station for adjusting said path to govern the setting of the gain at the unattended station.

3. In a signal transmission line having two separated stations thereon, a gain control amplifier at one of said stations, a gain control path extending between said stations and having a resistance variation according to temperature variations, means controlled by said path for governing the gain of said amplifier according to the resistance variations of the path, and an adjustable resistance element in said path and located at a distance from said amplifier for adjusting the setting of the gain of said amplifier.

4. In a signal transmission line having attended and unattended gain control stations thereon, a gain control amplifier at the unattended station, means comprising a bridge circuit for governing the operation of said amplifier, pilot wire means extending between said stations and included in one arm of said bridge circuit for controlling the gain at the unattended station, and resistance means at the attended station for varying the resistance of said pilot wire means to control the setting of the gain of the amplifier at the unattended station.

5. In a signal transmission line, having attended and unattended gain control stations thereon, a gain control amplifier at each of said stations, a bridge circuit at the unattended station, means controlled by said bridge for controlling the amplifier at the unattended station, a pilot path extending between the two stations and included in one arm of said bridge circuit for controlling the bridge to govern the gain at the unattended station, and means at the attended station for varying the resistance of said pilot path to control the setting of the bridge circuit and the control means at the unattended station.

6. In a signal transmission line having an attended gain control station and an unattended gain control station thereon, a gain control path extending between said stations, a gain control amplifier located at said unattended station, a bridge circuit having said path included therein in order to be controlled according to the resistance variations of the path, means controlled by said bridge for governing the gain effected by said amplifier, and means comprising a variable resistance element included in said path at the attended station for controlling the setting of the bridge at the unattended station.

7. In a signal transmission line having an attended gain control station and an unattended gain control station thereon, a gain control path extending between said stations, a bridge circuit having said path included therein in order to be controlled according to the resistance in variations of said path, means controlled by said bridge for governing the gain on the transmission line at the unattended station, and means located at the attended station for varying the resistance of the pilot path to change the setting of said bridge.

8. In a signal transmission line having an attended gain control station and an unattended gain control station thereon, a pilot line extending between the two stations and having a source of current included therein, a resistance element at the unattended station having a high temperature coefficient of resistance, means controlled by said pilot line according to the temperature thereof for governing the temperature of said resistance element, means controlled by said resistance element for governing the gain on the transmission line at the unattended station and a variable resistance element in the pilot line at the attended station for varying the pilot line resistance to control the setting of the gain at the unattended station.

9. In a signal transmission line having attended and unattended gain control stations thereon, a pilot line extending between said stations, a heater coil connected to the pilot line at the unattended station, a resistance element having a high temperature coefficient of resistance heated by said coil, means controlled by said resistance element for governing the gain on the transmission line at the unattended station, and a variable resistance element in said pilot line at the attended station for controlling the setting of the temperature of the resistance element.

10. In a signal transmission line having an attended gain control station and an unattended gain control station thereon, a pilot line extending between the two stations, a source of current connected to said pilot line, a gain control amplifier at the unattended station, a resistance element at the unattended station having a high temperature coefficient of resistance, means controlled by the variations in resistance of said pilot line with temperature changes for controlling the heating of said resistance element, means controlled by said resistance element for governing the operation of said amplifier, and a variable resistance element in said pilot line at the attended station for varying the pilot line resistance to control the setting of said amplifier.

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